Insulating to relativistic quantum Hall transition in disordered graphene

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Supplementary material

Photoemission measurements.

Graphene was grown on 4H-SiC(0001) undoped wafers, the growth conditions are destailed in the Methods section of the paper. After graphitization, the sample is characterized with Raman, XPS and ARPES techniques.

The experimental C 1s spectra and their fitting are reported in Fig. 1s for the graphene layer. Raw data represented by black dots are shown together with the results of the curve fitting of the C 1s spectra. Using asymmetrical shape for the graphene component, three contributions have to be considered to obtain consistent fits using a least-square fitting procedure: the small (IL) component located at 285.3 eV, the stronger one (G) at 284.5 eV, and the bulk (SiC) component at 283.6 eV. These doublets (IL and G) can be, respectively, ascribed to interface layer and to graphene layer. No other chemically shifted peak is needed to fit the spectrum. The number of layers present in each of our simples was calculated using a simple attenuation model applied to our photoemission results. Assuming homogeneous two-dimensional graphene growth, we can estimate the thickness of graphene. The estimation of the thickness for our sample was 1.2 monolayer.

Longitudinal contribution to the Hall resistivity.

We found in several measurements that the low field (B less equal 300 mT) shows a kink which looks almost like a plateau around zero field. This is due to a geometrical term coming from inhomogeneity of the sample, which arises from the square geometry of our Hall bar and the high zero field value of the longitudinal resistivity. In Fig. 2 we plot a zoom around zero of the Hall magnetoresistance and the corresponding symmetric $(\rho(\mathrm{B}) + \rho(-\mathrm{B}))/2$ and antisymmetric $(\rho(\mathrm{B}) - \rho(-\mathrm{B}))/2$ components.

The low field ρ_{xy} antisymmetric term $(\rho(\mathrm{B}) - \rho(-\mathrm{B}))/2$ is linear as expected for the classical Hall effect. We remark that at high temperature (with $k_F l_e$ greater than 1) the slope is not temperature dependent, with a dependence arising at lower T. The symmetric term $(\rho(\mathrm{B}) + \rho(-\mathrm{B}))/2$ is attributed to contribution of the longitudinal resistivity, indeed it shows a peak which increases at lower field. From this data, we estimate a contribution on the order of few percent of ρ_{xx} on ρ_{xy}. This peak also explains the presence of an apparent crossing point

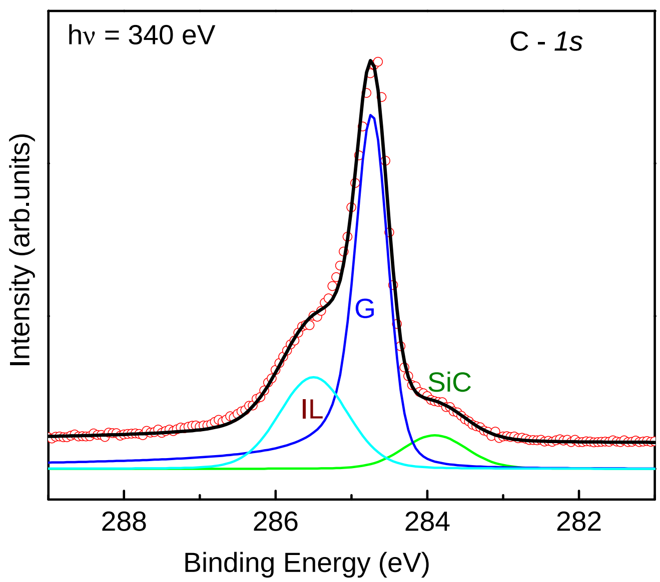

FIG. 1. XPS spectra, the contribution coming from Substrate, Interface, and Graphene are represented.

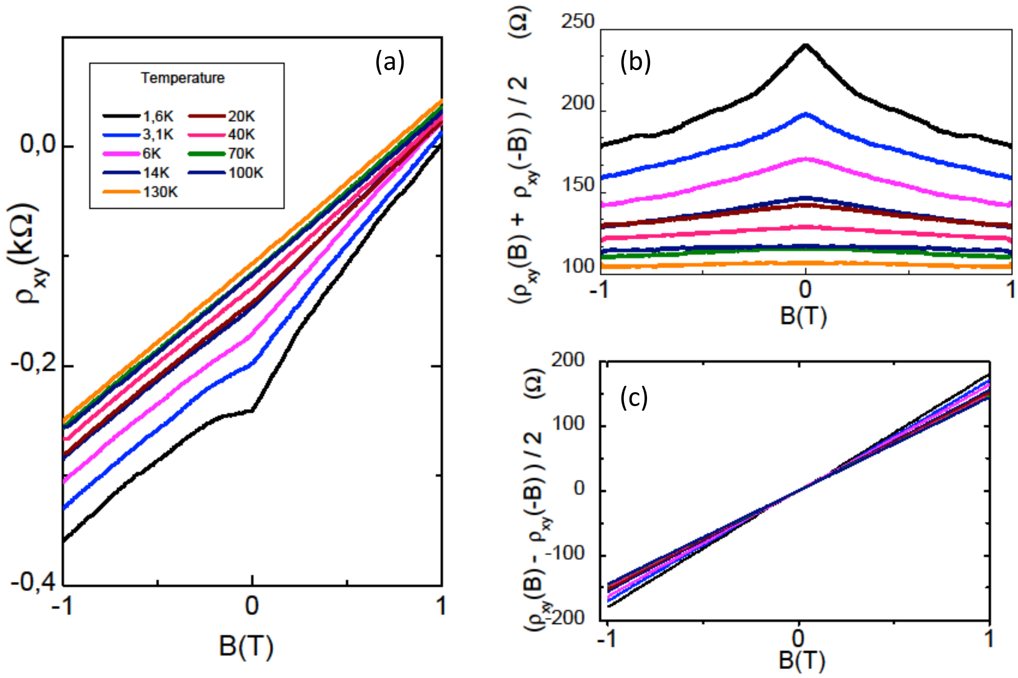

FIG. 2. (a) Kink in the low field Hall magnetoresistivity. (b-c) Symmetric and anti-symmetric components of the Hall magnetoresistivity. In the symmetric term we can see the contribution arising from longitudinal zero field resistivity peak, while the antisymmetric part is linear, as expected for a classical Hall term.